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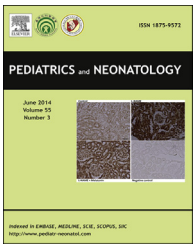

ORIGINAL ARTICLE

Hyperactivity and Impulsivity in Children with Untreated Allergic Rhinitis: Corroborated by Rating Scale and Continuous Performance Test

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Key Words
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Background: Allergic rhinitis (AR) is the most common chronic allergic disease in school-age children. An increased prevalence of attention deficit hyperactivity disorder (ADHD) in AR patients has been reported; however, inattention and hyperactivity in AR children have not been investigated using objective and scientific measurements.

Methods: We used AR symptom score, ADHD symptom scale, and computerized continuous performance test (CPT) to study the attention and impulsivity in AR children, age-matched controls, and ADHD children (aged 6–15 years). Univariate and multivariate linear regression analyses were applied to identify risk factors for impulsivity and inattention in AR children.

Results: Twenty-nine controls, 10 ADHD, and 105 AR children were enrolled. There were no differences in age and sex among the three groups. The scores of Hyperactivity/Impulsivity subscales of ADHD symptoms from both parents and teachers were significantly higher in the AR children. The CPT in AR children revealed higher commission errors, shorter reaction times, and more perseveration. Risk factors for inattention and impulsivity in AR children included younger age, male sex, higher AR symptom scores, persistent AR, moderate/severe AR, multiple atopic diseases, family history of atopy, and possible comorbidity with ADHD.

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Conclusion: Care for AR children should not only involve treating their allergy, but also monitoring the possible comorbidities of impulsivity and inattention. In children with impulsivity, AR should be considered in addition to ADHD.

1. Introduction

Allergic rhinitis (AR) is clinically defined as a symptomatic disorder of the nose induced after exposure to allergens by an immunoglobulin E (IgE)-mediated inflammation.[1] AR is the most common chronic allergic disease in school-age children.[2,3] The self-reported prevalence rates of the symptoms of ever having had rhinitis and current rhinitis were 53.5% and 43.6%, respectively, in 13- to 14-year-old children in Taipei during the phase 3 survey of The International Study of Asthma and Allergies in Childhood between December 2001 and January 2002.[4] Compared with the Phase 1 survey in 1994, the prevalence of rhinitis symptoms in the past 12 months increased by 1.5-fold.[4] AR is clinically diagnosed and its symptoms are rhinorrhea, nasal obstruction, itching, and sneezing. AR is subdivided into intermittent or persistent disease according to the duration of active symptoms, and the severity of AR can be classified as mild or moderate/severe according to the level of disturbance of the daily activities.[5] Various authors have also proposed symptom severity scales [e.g., Total Nasal Symptom Score (TNSS)].[6–8] Objective tests for IgE-mediated allergy are the skin prick test and serum-specific IgE [e.g., multiple-antigen simultaneous test (MAST) and Phadiatop].[1,9]

Attention deficit hyperactivity disorder (ADHD) is characterized by developmentally inappropriate symptoms of inattention, hyperactivity, and impulsivity apparent before the age of 7 [Diagnostic and statistical manual of mental disorders IV edition text revision (DSM-IV-TR)].[10] Although many individuals present with symptoms of both inattention and hyperactivity—impulsivity (the combined type), there are individuals in whom one or the other pattern is predominant: that is, the predominantly inattentive type and the predominantly hyperactive—impulsive type. The diagnosis and classification of ADHD totally depend on clinical observations of their behavior. Both the Chinese version and the original English version of the Swanson, Nolan, and Pelham, version IV (SNAP-IV) Rating Scale (RS) are reliable and valid instruments to rate ADHD-related symptoms.[11] In addition, ADHD is associated with a high risk of comorbidities, including oppositional defiant disorder or conduct disorder, affective/anxiety disorders, learning disorders, Tourette's disorder, and obsessive-compulsive disorder.[12,13]

In addition to physical complications, mental complications such as sleep disturbance, poor school performance, and hyperactivity have also been reported in AR children related to their nasal allergies.[14] Brawley et al reported that 10 of 23 (43%) ADHD children had typical physical signs of AR.[15] An increased prevalence and odds ratio (OR) of ADHD in AR patients were also noted in a study using the National Health Insurance Research Database (NHIRD) in Taiwan.[16] However, inattention and hyperactivity in AR children are yet to be investigated using objective and scientific measurements.

The aim of this study was to investigate whether attention and impulsivity control in AR children differed from a control group, and, if differences did exist, whether clinical parameters were able to predict these differences in AR children.

2. Methods

2.1. Study participants

Children aged 6—14 years (Grades 1—8) with two or more of the symptoms of watery rhinorrhea, sneezing, nasal obstruction, nasal pruritus for more than 1 hour on most days were enrolled as possible AR patients in accordance with the Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 guidelines.[1] After enrollment, blood sampling for serum-specific IgE (MAST or Phadiatop tests) was performed, and the patients with increased serum-specific IgE levels were considered as AR patients for this study. The AR patients were further classified as intermittent-mild, intermittent-moderate/severe, persistent-mild, and persistent-moderate/severe groups according to the ARIA 2008 guidelines.[1] The AR therapy such as antihistamines and corticosteroids can influence cognition and performance,[17,18] and therefore, we only enrolled AR children who were not taking any medication. Considering both the overview of the general AR children and excluding the confounding effect of the comorbidity with ADHD (cADHD), we further separated the pure AR children, that is, those without the possible comorbidity of ADHD, from the total AR group to compare their inattention and impulsivity scores with the control and pure ADHD groups. Age-matched children without AR or ADHD were enrolled as the control group. Because the focus of this study was inattention and impulsivity, we also enrolled age-matched pure ADHD children, defined as those fulfilling the DSM-IV diagnostic criteria of ADHD but without AR. Children with mental retardation, developmental delay, or epilepsy were excluded from this study. This study was approved by the Research Ethics Review Committee of Far Eastern Memorial Hospital, and the participants and their parents signed informed consent forms before assessment.

2.2. AR symptom scores

The AR symptom scores reflect disease severity. Many studies have used AR symptom scores as enrollment criteria

Table 1 Epidemiology data and AR symptom scores.

	Control (n = 29)	Total AR (n = 105)	Pure ADHD (n = 10)	p
Age	10.91 ± 2.77	10.78 ± 2.57	9.35 ± 2.20	0.223
Sex (M/F)	12/17	58/47	5/5	0.426
TNSS	0.33 ± 0.62	5.57 ± 2.69*	1.00 ± 1.41	<0.001
T5SS	0.67 ± 1.11	6.79 ± 3.39*	1.50 ± 2.12	<0.001

Sex (M/F) is presented as the number of participants. All other data are presented as mean ± standard deviation.
ADHD = attention deficit hyperactivity disorder; AR = allergic rhinitis; T5SS = Total Five Symptom Score; TNSS = Total Nasal Symptom Score.
* $p < 0.001$, compared with the control group (one-way analysis of variance followed by Dunnett *post hoc* test).

or outcome measures,[6,8,19,20] of which the TNSS and Total Five Symptom Score (T5SS) were the most common. The TNSS records sneezing, rhinorrhea, nasal itching, and nasal congestion,[19,20] and the T5SS records the same four symptoms plus eye itching.[6] All symptoms were graded on a 4-point scale using the following system: 0 = none, 1 = mild (symptoms that were present but not particularly bothersome), 2 = moderate (symptoms that were bothersome but did not interfere with daily activities), and 3 = severe (symptoms that were bothersome and interfered with daily activities or disturbed sleep). The scores were summed to give the TNSS and T5SS.

2.3. SNAP-IV scale

The SNAP-IV scale is a 26-item questionnaire in a 4-point Likert scale that is used to evaluate ADHD symptoms and severity, and it is completed by parents and teachers.[21] The SNAP-IV scale consists of Inattention (IA), Hyperactivity/Impulsivity (HI), and Oppositional subscales. The 26 items include 18 for ADHD symptoms (9 for the IA subscale and 9 for the HI subscale) and eight for oppositional defiant disorder symptoms as defined in the DSM-IV. Each item was scored on a 0–3 scale similar to the ADHD-RS (0 = not at all, 1 = just a little, 2 = quite a bit, and 3 = very much). The Chinese version of the SNAP-IV has been reported to have satisfactory levels of reliability and concurrent validity.[22]

2.4. Continuous performance test

The continuous performance test (CPT) was developed by Rosvold et al in 1956[23] and is one the most widely used neuropsychological tests in patients with ADHD. The computerized CPT (Conners' CPT II; MULTI-HEALTH SYSTEMS INC., North Tonawanda, NY, USA) presents target and nontarget stimuli.[24] The test lasts for 14 minutes and primarily assesses attention and impulse control. In brief, the participants were required to respond to the stimuli on a computer screen by pressing the space bar for every letter except for the letter "X". Multiple dependent measures existed, including omissions, commissions, hit reaction time (RT), variability of standard error, and detectability (d′). The confidence index (percentile) combined all of the CPT data to provide a likelihood out of 100 that a significant attention problem existed. In terms of the reliability of the Conners' CPT II, the split-half reliability has been reported to be 0.66–0.95.[24]

2.5. Statistical analysis

One-way analysis of variance was used to analyze ages, AR symptom scores (TNSS and T5SS), ADHD scale scores (SNAP-IV and DSM-IV), and CPT scores among the control, AR, and ADHD groups. The ADHD scale scores and CPT scores between the different groups were further compared by two-sample t tests. The Chi-square test was used to compare sex distribution between the groups. Univariate linear regression analysis was used to investigate the association of inattention and impulsivity (statistically significant variables from SNAP-IV, DSM-IV, and CPT) with possible explanatory parameters (age, male sex, TNSS, T5SS, persistent AR, severe/moderate AR, multiple atopic diseases, family history of atopy (FH), possible cADHD) in the total AR group. "Possible cADHD" in the AR children was defined as AR children fulfilling the DSM-IV diagnostic

Table 2 SNAP-IV and DSM-IV-TR scores.

	Control	Pure AR	Total AR	Pure ADHD	p
SNAP-IA (parent)	7.36 ± 4.69	9.98 ± 6.35*, †††	10.93 ± 6.81**, ††	17.70 ± 4.76***	<0.001
SNAP-IA (teacher)	5.91 ± 3.15	7.99 ± 5.82†††	9.13 ± 6.27**, ††	16.80 ± 5.92***	<0.001
SNAP-HI (parent)	4.32 ± 4.27	7.61 ± 5.07**	8.59 ± 5.87**	9.80 ± 6.27**	0.002
SNAP-HI (teacher)	2.38 ± 2.86	4.89 ± 5.35*	6.39 ± 6.76***	8.00 ± 5.50*	0.031
DSM-IA (parent)	1.60 ± 1.66	2.90 ± 2.83**, ††	3.31 ± 3.01***, ††	6.20 ± 2.70***	<0.001
DSM-IA (teacher)	0.97 ± 0.93	2.02 ± 2.24*, †††	2.47 ± 2.61***, †††	6.05 ± 2.63***	<0.001
DSM-HI (parent)	0.92 ± 1.41	1.84 ± 2.07**	2.28 ± 2.36***	3.10 ± 3.48*	0.013
DSM-HI (teacher)	0.29 ± 0.59	1.22 ± 1.87**	1.71 ± 2.37***	2.00 ± 1.55**	0.036

All data are presented as mean ± standard deviation.
ADHD = attention deficit hyperactivity disorder; AR = allergic rhinitis; DSM-IV-TR = Diagnostic and Statistical Manual of Mental Disorders IV edition text revision; HI = Hyperactivity/Impulsivity subscale; IA = Inattention subscale; SNAP-IV = Swanson, Nolan, and Pelham, version IV Rating Scale.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, compared with the control group (two-sample t test).
††† $p < 0.001$; †† $p < 0.01$, compared the AR groups with the pure ADHD group (two-sample t test).

criteria of ADHD. Multivariate linear regression analysis of the significant explanatory parameters was then performed to build a model to predict inattention and impulsivity in AR children. All data were analyzed using IBM SPSS Statistics version 19.0 (IBM Inc., Somers, NY, USA). All tests were two-tailed and a p value less than 0.05 was considered statistically significant.

3. Results

3.1. Epidemiology data and AR symptom scores

Twenty-nine controls, 10 pure ADHD, and 105 AR children were enrolled in this study (Table 1). There were no differences in age or sex distribution among the groups. The AR symptom scores (TNSS and T5SS) were significantly higher in the AR group (both $p < 0.001$). The higher AR symptom scores corroborated the rhinitis features of the AR group. There were no differences in TNSS and T5SS between the control group and pure ADHD group.

3.2. SNAP-IV and DSM-IV-TR scores

Among the 105 AR children, 12 (11.4%) fulfilled the DSM-IV-TR diagnostic criteria of ADHD, and the remaining 93 (88.6%) were assigned as the pure AR group. Responses to questionnaires collected from the parents and teachers showed significant differences in IA and HI subscales among the control, total AR, and pure ADHD groups (Table 2). Compared with the control group, both the AR and ADHD groups showed significantly increased scores of IA and HI subscales from both the parents and teachers. There were no differences in the scores of HI subscales between the AR and ADHD groups; however, the ADHD group had significantly higher scores in the IA subscales than the AR group. Excluding the possible comorbidity of ADHD, the pure AR group still had significantly higher scores of all IA and HI subscales, except for the IA subscale of SNAP-IV as reported by the teachers, than the control group.

3.3. CPT

In the CPT, there were significant differences in commission errors (responses to nontargets, i.e., X's) and marginal differences in hit RT among the control, total AR, and pure ADHD groups (Table 3). Compared with the control group, the AR group had significant increases in commission errors and perseverations, whereas the pure ADHD group had significant increases in hit RT standard error and variability, and marginal increases in commission errors and detectability. Compared with the AR and ADHD groups, the AR group had significantly shorter hit RT and marginal decreases in hit RT standard error.

3.4. Risk factors for inattention and impulsivity in the AR children

Because the AR children showed higher inattention and impulsivity than the control group, we further investigated possible risk factors to predict the inattention and impulsivity in the AR children. The significant impulsivity parameters (HI subscales of SNAP-IV and DSM-IV-TR from the parents and teachers, commissions, hit RT) and significant inattention parameters (IA subscales of SNAP-IV and DSM-IV-TR from the parents and teachers) were used as the dependent variables. The independent/explanatory variables (age, male sex, TNSS, T5SS, persistent AR, moderate/severe AR, multiple atopic diseases, family history of atopy, and cADHD) were selected. Univariate/simple linear regression analysis revealed that the significant risk factors included age (for IA and HI subscales of SNAP-IV and DSM-IV-TR from the parents and hit RT), male sex (for IA subscales of SNAP-IV and DSM-IV-TR from the teachers and HI subscale of SNAP-IV from the teachers), TNSS/T5SS (for HI subscales of SNAP-IV and DSM-IV-TR from the parents), persistent AR

Table 3 Continuous performance test.

	Control	Pure AR	Total AR	Pure ADHD	p
Confidence index	32.56 ± 14.82	36.17 ± 17.95	37.61 ± 17.93	42.07 ± 18.11	0.250
Omissions	35.52 ± 20.12	34.86 ± 18.27	35.48 ± 18.66	41.71 ± 19.89	0.612
Commissions	29.90 ± 31.97	46.13 ± 30.95*	45.17 ± 31.16*	52.74 ± 30.83^{m}	0.046
Hit RT	44.64 ± 32.85	33.75 ± 26.08†	36.13 ± 27.07†	54.73 ± 26.61	0.080
Hit RT SE	30.41 ± 24.83	33.93 ± 27.72$^{(m)}$	35.80 ± 27.26	51.59 ± 30.98*	0.109
Variability	29.54 ± 25.28	36.88 ± 31.09	38.74 ± 30.71	50.18 ± 32.35*	0.141
Detectability (d′)	37.26 ± 27.45	47.82 ± 29.70	46.70 ± 29.63	56.60 ± 25.44^{m}	0.145
Response style (B)	44.47 ± 27.83	37.91 ± 19.46	38.59 ± 19.12	46.73 ± 24.24	0.287
Perseverations	37.78 ± 12.10	44.78 ± 24.98	45.56 ± 25.70*	44.48 ± 23.00	0.302
Hit SE block change	44.06 ± 22.51	49.56 ± 25.99	50.82 ± 26.45	52.69 ± 28.20	0.442
Hit RT ISI change	36.05 ± 21.80	39.53 ± 23.74	41.25 ± 24.25	47.38 ± 26.28	0.392
Hit SE ISI change	39.26 ± 22.92	41.07 ± 27.69	42.57 ± 27.62	48.59 ± 33.21	0.640

All data are presented as mean ± standard deviation, and as percentiles of the general population, except confidence index, which is expressed as chance out of 100.
^{m} p <0.1; *: $p < 0.05$, compared with the control group (two-sample t test).
^{m} p <0.1; †: $p < 0.05$, compared the AR groups with the pure ADHD group (two-sample t test).
ADHD = attention deficit hyperactivity disorder; AR = allergic rhinitis; RT = reaction time; SE = standard error; ISI = interstimulus interval.

(for HI subscales of SNAP-IV and DSM-IV-TR from the parents), moderate/severe AR (for commissions and hit RT), multiple atopic diseases (for IA subscale of SNAP-IV from the teachers), family history of atopy (for hit RT), and cADHD (for IA and HI subscales of SNAP-IV and DSM-IV-TR from the parents and teachers and hit RT) (Table 4).

The hit RT and HI subscale of SNAP-IV and DSM-IV-TR from the parents had the largest numbers of significant independent variables among all dependent variables. Both had five significant independent variables. We took the HI subscale of SNAP-IV from the parents and hit RT as the dependent variables for further multivariate linear regression analysis (Table 5). A four-parameter linear regression model was obtained for the HI subscale of SNAP-IV from the parents: HI subscale = 13.616 − 0.927 × age + 7.693 × cADHD + 3.065 × persistent AR + 0.379 × TNSS (R^2 = 0.351, $p < 0.001$). According to standardized β, cADHD had the largest effect for the HI subscale of SNAP-IV from the parents, followed by age, persistent AR, and TNSS, in that order. cADHD, persistent AR, and TNSS were positively correlated with HI subscale, whereas age was negatively correlated. A three-parameter linear regression model was obtained for hit RT: hit RT = 73.613 − 2.432 × age − 15.118 × moderate AR − 8.288 × positive FH (R^2 = 0.161, $p = 0.003$). According to standardized β, moderate/severe AR had the largest effect for hit RT, followed by age and family history of atopy, in that order. Moderate/severe AR, age, and family history of atopy were all negatively correlated with hit RT.

Table 4 Univariate linear regression analysis of significant dependent variables from SNAP-IV, DSM-IV, and continuous performance test in the total AR group.

Dependent variables	Independent variables	β	SE	*p*
IA (SNAP-IV, parent)	Age	−0.686	0.265	0.011
	cADHD	7.819	1.806	<0.001
IA (SNAP-IV, teacher)	Male	2.508	1.543	0.109
	Multiple atopy	2.121	1.576	0.184
	cADHD	10.725	1.604	<0.001
HI (SNAP-IV, parent)	Age	−0.934	0.217	<0.001
	TNSS	0.352	0.226	0.123
	T5SS	0.308	0.179	0.089
	Persistent AR	2.273	1.427	0.115
	cADHD	6.300	1.578	<0.001
HI (SNAP-IV, teacher)	Male	2.976	1.655	0.077
	cADHD	11.119	1.772	<0.001
IA (DSM-IV, parent)	Age	−0.242	0.119	0.044
	cADHD	3.213	0.810	<0.001
IA (DSM-IV, teacher)	Male	0.881	0.646	0.177
	cADHD	4.495	0.664	<0.001
HI (DSM-IV, parent)	Age	−0.290	0.091	0.002
	TNSS	0.116	0.089	0.198
	T5SS	0.118	0.071	0.099
	Persistent AR	0.893	0.561	0.115
	cADHD	2.749	0.626	<0.001
HI (DSM-IV, teacher)	cADHD	3.720	0.637	<0.001
commissions	Moderate AR	10.392	7.197	0.153
Hit RT	Age	−2.842	1.089	0.011
	Persistent AR	−9.760	5.609	0.086
	Moderate AR	−15.281	5.765	0.010
	FH	−7.552	5.455	0.170
	cADHD	22.516	8.075	0.006

Only independent variables with $p < 0.2$ are listed.
ADHD = attention deficit hyperactivity disorder; AR = allergic rhinitis; cADHD = possible comorbidity with ADHD, possible comorbidity with ADHD; DSM-IV = Diagnostic and Statistical Manual of Mental Disorders IV edition; FH = family history of atopy; HI = Hyperactivity/Impulsivity subscale; IA = Inattention subscale; moderate AR = moderate/severe AR; RT = reaction time; SNAP-IV = Swanson, Nolan, and Pelham, version IV Rating Scale; T5SS = Total Five Symptom Score; TNSS = Total Nasal Symptom Score.

4. Discussion

Previous studies have focused on the epidemiological associations between ADHD and AR.[15,16] Brawley et al investigated 30 ADHD children and reported that 80% had AR symptoms, 43% had typical physical signs of AR, and 61% had positive prick skin test results. Chou et al analyzed 469 ADHD cases from the NHIRD in Taiwan and reported an increased rate of AR in ADHD patients compared with the general population (OR = 1.83; 95% confidence interval = 1.48−2.27; $p < 0.001$).[25] Shyu et al also analyzed the NHIRD and reported that allergic children (including those with AR, bronchial asthma, atopic dermatitis) had a higher prevalence rate of ADHD than the general population (0.9% vs. 0.5%, $p < 0.001$).[26] In addition, children with AR and bronchial asthma but not atopic dermatitis had a higher risk of being associated with ADHD, and the main contributing factor was AR.[26] Tsai et al further investigated AR children from the same database and reported that AR children also had a higher prevalence of ADHD than the general population (1.0% vs. 0.5%, $p < 0.001$).[16] The main limitations of these three studies using the NHIRD were (1) proper and correct diagnosis coding could not be guaranteed from an electronic database; (2) the association between the severity of the symptoms of the allergic diseases and ADHD was not discussed; and (3) the association of ADHD symptoms with allergic diseases was not investigated.

The current study first investigated the severity of inattention and impulsivity in AR children after a correct diagnosis and then recorded their symptom scoring of AR and ADHD.

The results demonstrated that AR children had higher ADHD symptom scores (SNAP-IV and DSM-IV-TR; Table 2) and commission errors (CPT; Table 3) than the control children. After excluding those with the possible comorbidity of ADHD and excluding the interference by AR therapy, the untreated pure AR children still showed higher inattention and impulsivity than the control group in the symptom-scoring questionnaires (SNAP-IV and DSM-IV-TR; Table 2) and computerized test (CPT; Table 3). Furthermore, we suggest that impulsivity was a more significant issue than inattention in the AR children based on three findings. First, the differences in impulsivity scores between the AR and control children were more significant than inattention scoring ($p < 0.01$ in the HI subscale vs. $p < 0.05$ in the IA

Table 5 Multivariate linear regression model for HI subscale (SNAP-IV, parent) in the total AR group.

Independent variables	HI subscale ($R^2 = 0.351$, $p < 0.001$)			Hit RT ($R^2 = 0.161$, $p = 0.003$)		
	β (SE)	Standardized β	*p*	β (SE)	Standardized β	*p*
Age	−0.927 (0.240)	−0.373	<0.001	−2.432 (1.004)	−0.247	0.018
cADHD	7.693 (1.973)	0.375	<0.001	—	—	—
Persistent AR	3.065 (1.325)	0.239	0.024	—	—	—
Moderate AR	—	—	—	−15.118 (5.569)	−0.276	0.008
TNSS	0.379 (0.233)	0.168	0.108	—	—	—
FH	—	—	—	−8.288 (5.202)	−0.162	0.115

AR = allergic rhinitis; cADHD = possible comorbidity with ADHD, possible comorbidity with ADHD; FH = family history of atopy; HI = Hyperactivity/Impulsivity; moderate AR = moderate/severe AR; RT = reaction time; SE = standard error; SNAP-IV = Swanson, Nolan, and Pelham, version IV; TNSS = Total Nasal Symptom Score.

subscale of SNAP-IV from the parents; Table 2). Second, the impulsivity scoring of the AR children showed no difference to the pure ADHD children. Third, the AR children showed increased commission errors and shorter RT in the CPT than the control children (Table 3). The response pattern of a faster RT but more commission errors is usually associated with an impulsive style.[24] Impulsivity in atopic patients was corroborated by Runeson et al's finding that asthma was associated with higher impulsiveness scores.[27]

After univariate linear regression analysis to identify the variables that may be responsible for the impulsivity and inattention in the AR children (Table 4), the significant independent variables included age, male sex, AR symptom scores and persistence, moderate/severe AR, and family history of atopy, possible cADHD, and multiple atopic diseases. For age, the ORs for ADHD in AR and allergic children have been reported to be highest between 6 and 11 years of age, and decreasing thereafter.[16,26] Likewise in our study, age had a negative effect on IA and HI subscales from the parents. With increasing age, the severities of impulsivity and inattention decreased. In addition, hit RT (expressed as percentile of the general population) of the AR children decreased as their age increased. With regard to sex, boys with ADHD have been reported to be more likely to be impulsive than girls,[22,28] and AR boys have been reported to have a higher risk of ADHD than girls.[16] In the current study, the AR boys also had higher scores in the HI subscale of SNAP-IV from the teachers. In addition, male sex also had a positive effect on the IA subscales from the teachers, and was a risk factor for inattention and impulsivity. With regard to AR symptom scores and persistence, the TNSS/T5SS and persistent AR had positive effects on the HI subscales from the parents. That is, children with higher symptom scores of AR or persistent AR had a higher risk of impulsivity. Persistent AR was also correlated with a shorter RT, which is also an indicator of impulsivity. Both moderate/severe AR (disturbing daily activities or sleep) and a family history of atopy had a negative impact on hit RT. Moderate/severe AR also had a positive effect on commission errors. Therefore, moderate/severe AR and a family history of atopy were risk factors for impulsivity. Possible cADHD, not surprisingly, strongly predicted higher scores of IA and HI subscales in the AR children. cADHD was also positively correlated with hit RT. That is, the AR children with cADHD had a longer hit RT more like the performance of the pure ADHD children in the CPT (Table 3). Multiple atopic diseases predicted higher scores in the IA subscale of SNAP-IV from the teachers.

Although we generated a multivariate linear regression model for the HI subscale of SNAP-IV from the parents and hit RT in Table 5, interpretation of hit RT related to impulsivity and inattention should be done with caution. Atypically fast RT when combined with an unusually large percentage of commission errors may indicate impulsivity, whereas very slow RT coupled with a large percentage of omissions and/or commissions can indicate inattentiveness.[24] Identifying a child's performance on the CPT as an impulsive style or inattentive style need to take into consideration hit RT, commission errors, omission errors, perseveration, and detectability as a whole.

In conclusion, this is the first study to investigate the correlation between AR severity and ADHD symptom scoring in children. The AR children scored higher in ADHD symptom questionnaire and made more commission errors in the CPT than the control children. Eliminating the possible comorbidity between AR and ADHD and excluding interference by AR therapy, the untreated pure AR children still showed higher impulsivity and inattention than the control children. Impulsivity was a greater problem than inattention in the AR children. Potential risk factors for impulsivity and inattention in the AR children were younger age, male sex, higher AR symptom scores, persistent AR, moderate/severe AR, multiple atopic diseases, family history of atopy, and possible cADHD. Pediatricians caring for AR children should not only treat their allergy but also the possible comorbid impulsivity and inattention, especially in AR children with potential risk factors. In addition, in children with impulsivity and inattention, allergic diseases, and especially AR, should be considered in addition to ADHD.

Conflict of interest

The authors state that there are no conflicts of interest regarding the publication of this article.

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References

1. Bousquet J, Khaltaev N, Cruz AA, Denburg J, Fokkens WJ, Togias A, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA^{2}LEN and AllerGen). *Allergy* 2008;**63**:8—160.
2. Hwang CY, Chen YJ, Lin MW, Chen TJ, Chu SY, Chen CC, et al. Prevalence of atopic dermatitis, allergic rhinitis and asthma in Taiwan: a national study 2000 to 2007. *Acta Derm Venereol* 2010;**90**:589—94.
3. Liao MF, Liao MN, Lin SN, Chen JY, Huang JL. Prevalence of allergic diseases of schoolchildren in Central Taiwan. From ISAAC surveys 5 years apart. *J Asthma* 2009;**46**:541—5.
4. Yan DC, Ou LS, Tsai TL, Wu WF, Huang JL. Prevalence and severity of symptoms of asthma, rhinitis, and eczema in 13- to 14-year-old children in Taipei, Taiwan. *Ann Allergy Asthma Immunol* 2005;**95**:579—85.
5. Bousquet J, Van Cauwenberge P, Khaltaev N, Aria Workshop Group; World Health Organization. Allergic rhinitis and its impact on asthma. *J Allergy Clin Immunol* 2001;**108**:S147—334.
6. Baiardini I, Villa E, Rogkakou A, Pellegrini S, Bacic M, Compalati E, et al. Effects of mometasone furoate on the quality of life: a randomized placebo-controlled trial in persistent allergic rhinitis and intermittent asthma using the Rhinasthma questionnaire. *Clin Exp Allergy* 2011;**41**:417—23.
7. Mimura T, Usui T, Mori M, Aixinjueluo W, Funatsu H, Noma H, et al. Immunochromatographic assay for measurement of total IgE in tears, nasal mucus, and saliva of patients with allergic rhinoconjunctivitis. *J Asthma* 2010;**47**:1153—60.
8. Maiti R, Rahman J, Jaida J, Allala U, Palani A. Rupatadine and levocetirizine for seasonal allergic rhinitis: a comparative study of efficacy and safety. *Arch Otolaryngol Head Neck Surg* 2010;**136**:796—800.
9. Liu YH, Chou HH, Jan RL, Lin HJ, Liang CC, Wang JY, et al. Comparison of two specific allergen screening tests in different patient groups. *Acta Paediatr Taiwan* 2006;**47**:116—22.
10. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders (DSM-IV-TR)*. 4th ed. Washington, DC: American Psychiatric Association; 2000.
11. Gau SS, Shang CY, Liu SK, Lin CH, Swanson JM, Liu YC, et al. Psychometric properties of the Chinese version of the Swanson, Nolan, and Pelham, version IV scale—parent form. *Int J Methods Psychiatr Res* 2008;**17**:35—44.
12. Robertson MM. Attention deficit hyperactivity disorder, tics and Tourette's syndrome: the relationship and treatment implications. A commentary. *Eur Child Adolesc Psychiatry* 2006;**15**:1—11.
13. Pliszka SR. Comorbidity of attention-deficit/hyperactivity disorder with psychiatric disorder: an overview. *J Clin Psychiatry* 1998;**59**:50—8.
14. Blaiss MS. Pediatric allergic rhinitis: physical and mental complications. *Allergy Asthma Proc* 2008;**29**:1—6.
15. Brawley A, Silverman B, Kearney S, Guanzon D, Owens M, Bennett H, et al. Allergic rhinitis in children with attention-deficit/hyperactivity disorder. *Ann Allergy Asthma Immunol* 2004;**92**:663—7.
16. Tsai MC, Lin HK, Lin CH, Fu LS. Prevalence of attention deficit/hyperactivity disorder in pediatric allergic rhinitis: a nationwide population-based study. *Allergy Asthma Proc* 2011;**32**:41—6.
17. Kay GG. The effects of antihistamines on cognition and performance. *J Allergy Clin Immunol* 2000;**105**:S622—7.
18. Stuart FA, Segal TY, Keady S. Adverse psychological effects of corticosteroids in children and adolescents. *Arch Dis Child* 2005;**90**:500—6.
19. Meltzer EO, LaForce C, Ratner P, Price D, Ginsberg D, Carr W. MP29-02 (a novel intranasal formulation of azelastine hydrochloride and fluticasone propionate) in the treatment of seasonal allergic rhinitis: a randomized, double-blind, placebo-controlled trial of efficacy and safety. *Allergy Asthma Proc* 2012;**33**:324—32.
20. Satdhabudha A, Poachanukoon O. Efficacy of buffered hypertonic saline nasal irrigation in children with symptomatic allergic rhinitis: a randomized double-blind study. *Int J Pediatr Otorhinolaryngol* 2012;**76**:583—8.
21. Bussing R, Fernandez M, Harwood M, Wei Hou, Garvan CW, Eyberg SM, et al. Parent and teacher SNAP-IV ratings of attention deficit hyperactivity disorder symptoms: psychometric properties and normative ratings from a school district sample. *Assessment* 2008;**15**:317—28.
22. Liu YC, Liu SK, Shang CY, Lin CH, Tu CL, Gau SSF. Norm of the Chinese version of the Swanson, Nolan and Pelham, version IV scale for ADHD. *Taiwanese J Psychiatry* 2006;**20**:290—304.
23. Beck LH, Bransome Jr ED, Mirsky AF, Rosvold HE, Sarason I. A continuous performance test of brain damage. *J Consult Psychol* 1956;**20**:343—50.
24. Conners CK, Staff MHS. *Conners' continuous performance test (CPT II) for Windows technical guide and software manual*. North Tonawanda: Multi-Health Systems Inc.; 2004.
25. Chou PH, Lin CC, Lin CH, Loh el-W, Chan CH, Lan TH. Prevalence of allergic rhinitis in patients with attention-deficit/hyperactivity disorder: a population-based study. *Eur Child Adolesc Psychiatry* 2013;**22**:301—7.
26. Shyu CS, Lin HK, Lin CH, Fu LS. Prevalence of attention-deficit/hyperactivity disorder in patients with pediatric allergic disorders: a nationwide, population-based study. *J Microbiol Immunol Infect* 2012;**45**:237—42.
27. Runeson R, Wahlstedt K, Norbäck D. Pilot study of personality traits assessed by the Karolinska Scales of Personality (KSP) in asthma, atopy, and rhinitis. *Percept Mot Skills* 2011;**113**:909—20.
28. Hasson R, Fine JG. Gender differences among children with ADHD on continuous performance tests: a meta-analytic review. *J Atten Disord* 2012;**16**:190—8.